Energy Efficiency as a Tool of Climate Change Mitigation - A Case Study of Slovak Municipality

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***Abstract**: Climate change and its impact on the environment as well as the economies, is the defining issue of our era. At European level a comprehensive package of policy measures to reduce greenhouse gas emissions has been initiated through the European Climate Change Programme. Slovakia as one of the EU Member States has also an obligation to stimulate the energy efficiency measures in all sectors of national economy. This obligation will markedly affect the public sector, as there is a great potential of savings. The paper analyses the current Energy policy of the EU and Slovakia with the focus on their implications for municipalities. The application of selected tools of energy policy is demonstrated on the case study of the medium-sized municipality located in Eastern Slovakia. Municipalities in Slovak Republic are forced to energy costs reduction, though usually these actions are not systematic and efficient from economic, environmental or social point of view. The aim of the case study is to declare environmental and financial benefits as a result of energy efficiency measures implementation. The proposed changes, such as installation of LED technology in public lighting, municipality can achieve significant energy savings at a relatively rapid return on investment. Such economically available and environmentally effective solutions may serve as an example and also a motivation for other municipalities in their efforts to energy efficiency, CO_2 reduction and climate change mitigation.*

***Keywords**: energy efficiency, energy policy, municipality, CO_2 emissions, LED technologies.*

1 Introduction

In recent years, resource efficiency and the low-carbon society have emerged as central themes in global discussions on the transition to a green economy [10, 15]. EU commission is aiming to sustainability, competitiveness and safety in all stages of the energy chain [2, 3]. Energy efficiency policy and energy management is normally the responsibility of the government of each state [1, 8].

But a rising number of local authorities are starting to take charge of their own energy supply, a development known as municipal energy management. They aim to achieve energy self-sufficiency; in other words, they want to be as independent as possible of external sources of heat and power. Although energy efficiency and energy self-sufficiency brings a lot of advantages (better quality of environment, increased independency from external energy sources, green jobs opportunities, financial savings, etc.) [9, 11, 12], this form is popular mostly in Germany and Austria, but there are pilot energy self-sufficient municipalities also in Czech Republic and other countries. Municipalities in Slovak Republic are forced to energy costs reduction, though usually these actions are not systematic and efficient from economic, environmental or social point of view. [7] Also, current and upcoming climate change negatively affects Slovakia and its regions. Although the governments of towns and villages in Slovakia gained significant powers and tools because of the decentralization, they are relatively idle in the issues of adaptation to climate change. On the contrary, often we can meet with such decisions that adversely impact on climate change. The main reason for inactivity, respectively incorrect decision making of municipalities' representatives is the lack of knowledge about the threats arising from climate change for the region or locality and how to mitigate those threats, or face them. On the assumption that the effects of climate change have mainly local character, as well as the fact that local authorities are responsible for the development of its territory, including integrated impacts of climate change into decision making and normal activities on its territory, it is essential to increase their awareness and motivation and knowledge for good governance and sustainable development. Increasing energy efficiency is an important measure how municipalities can move towards climate change mitigation.

1.1 Energy Efficiency and the Low Carbon Economy – EU perspective

At the strategic level, EU policy sets out a broad framework for resource efficiency and climate change policy, including a variety of long-term (non-binding) objectives. For example, the Roadmap to a Resource Efficient Europe [6] includes a vision for 2050, wherein 'the EU's economy has grown in a way that respects resource constraints and planetary boundaries, thus contributing to global economic transformation … all resources are sustainably managed, from raw materials to energy, water, air, land and soil'. Similarly, the Roadmap to a low-carbon economy [5] stipulates that, by 2050, the EU should cut its emissions to 80% below 1990 levels through domestic reductions. These are complemented by policies addressing specific pressures and sectors. The EU's 2020 targets on greenhouse gas emissions and energy consumption [4] are prominent examples. In order to avoid 'dangerous interference with the climate system', the international community has agreed to limit the global mean temperature increase since pre-industrial times to less than 2°C [16]. In line with the Intergovernmental Panel on Climate Change assessment of the actions needed by developed countries to achieve the 2°C target, the EU aims to cut its greenhouse gas emissions by 80–

95% below 1990 levels by 2050 [5]. Pursuant to this overarching goal, European countries have adopted a number of policy measures, including international commitments under the Kyoto Protocol. For 2020, the EU has unilaterally committed to cut its emissions by at least 20% compared to 1990 levels [4].

1.2 Energy Policy in Slovakia

Energy industry is a sector that in the conditions of the Slovak republic represents the main producer of greenhouse gas emissions and thereby remarkably contributes to climate change. Reducing energy consumption directly reduces emissions (by reducing the consumption of fossil energy) or indirectly (the whole life cycle of energy production). While energy savings do not cause negative impacts, alternative energy sources (replacing fossil fuels) face to the several challenges and constraints (environmental, technical limitations, lower energy productiveness compared to fossil fuels, etc.). Awareness of the negatives and limitations of alternative energy sources to fossil fuels does not mean resignation to efforts to reduce greenhouse gas emissions from fossil sources. It gives us only a life-like picture and highlights the importance and priority of energy savings.

The European Parliament and the Council adopted in May 2010 a revised Directive on the Energy Performance of Buildings Directive 2010/31/EU, which is implemented also in Slovak legislation. For the government it is interesting that the Directive highlights positive examples of public buildings - the preamble states that the buildings occupied by public authorities should serve as an example of greening and energy-efficient approaches. The Directive specifies among other things, an obligation that all municipality buildings should by after 2020 nearly zero-energy buildings, and new buildings occupied and owned by public authorities have to be nearly zero energy buildings since 2018.

Energy consumption in our country is affected in particular the by consumption of heat, hot water and electricity consumption of electrical appliances and lighting [13]. Therefore, the most important areas of activity for energy saving measures at the municipal level are:

- Building heating system and hot water production (e. g. support for improving the energy performance of buildings, isolation and insulation of buildings and pipelines, installation of thermostats of other control systems, requiring low energy or passive standards in new buildings etc.).
- Efficient use of energy (e. g. rationalization of public lighting, rationalization of lighting in buildings, replacement of electric heating and hot water production).
- Efficient operation of energy equipment in buildings and facilities (avoiding oversized energy technology, ensuring efficient thermostatic control of heating elements, optimizing the preparation of heat and hot water, including tempering buildings, reducing distances of heat distribution).

Before changing to a sensible use of renewable energy sources, in terms of financial investment, it is first necessary to consider the actual energy needs and possibilities of energy savings, which are often cheaper and can be applied even faster. Although the use of renewable energy sources is associated with certain restrictions (fluctuation of available energy, higher investment costs), their use

leads to more positive effects not only for the environment but also for the social sphere; although the effects cannot always be precisely quantified. There are several ways to use renewable energy sources that can be applied in our country. When deciding on their use, it is necessary to consider not only their potential in a given region and capital costs associated with them, as well as environmental constraints and social acceptance of these sources in the particular municipality [14].

2 Materials and Methods

2.1 Case Study Research

According to [18] the case study is one of several ways of doing social science research. The findings of case study research, like experiments, are able to be generalised to theoretical propositions and not to population or universes, because with this methodology the aim is to generalise theories (analytic generalisation) and not to enumerate frequencies (statistical generalisation).
The criteria for choosing our case study research' municipality were related to three main issues:

- the municipality does not have applied measures to reduce CO_2 production, increase energy efficiency and adaptation to climate change but is aware of its environmental impacts and wants to improve this current state,
- due to the fact that case study research is an interactive process, it is necessary to detect motivation by the municipality to participate in it, as research demands several fields visits, which imply many time dedication from the participating municipality,
- municipality should consider that implementation of these measures requires real commitment and participation of its stakeholders, especially municipality representatives and habitants.

For our case study research, middle-sized municipality (1215 inhabitants) – Kracunovce, located in Eastern Slovakia was selected.
In the next part of this paper we will focus on the issue of increasing energy efficiency, CO_2 reduction and better adaptation to climate change in this municipality. It will require analysis of current state of using energy sources and providing proposals how this state can be improved. Analysis will also show economical comparison of current state and proposed solution.
In our case study we will focus on the main energy issues in this village:

- street lighting,
- building of municipal office.

3 Results and Discussion

In our case study village LED technology can be applied on street lighting as well as lighting in municipal office. Currently, for street lighting are used two types of light sources: compact fluorescent lamp 36W and sodium-vapour lamp with input power 70W. For lighting of main street we propose to use LED light with input power 65W and luminance 7 400 Lm and for other street communication we propose LED lights with input power 30W and luminance 3 200 Lm.

Comparison of economic aspects (energy consumption per hour and total energy consumption) as well as environmental aspects (CO_2 production) is summarized in Table 1.

Table 1
Comparison of energy consumption and CO_2 production – street lighting

Locality	**Energy consumption/hour ($kW.h^{-1}$)**		**Energy consumption/year ($kWh.year^{-1}$)**		**CO_2 production/year ($kg.kWh^{-1}$)***	
	Current state	After implementation	Current state	After implementation	Current state	After implementation
Main street	1260	1170	4710	4375	2920.2	2712.5
Local communications	3492	2910	13056	10880	8094.72	6745.6
Total	4752	4080	17766	15255	11014.92	9458.1

* CO_2 emission coefficient of electricity is 0.62 kg/kWh [17]

Although the differences in comparison to the original lamps appear to be small, they are not insignificant, because with lower power we get more of light. Other positives include long life (100.000 hours), an instant light colour throughout the life and modern design. In addition to achieve economic savings and environmental benefits in terms of reducing CO_2 emissions by 1 556.82 kWh per year.

For the lighting of municipal office is a currently used neon light. Using LED technology, the considerable economic savings can be achieved. Neon tubes 36W can be replaced by LED tubes with 18W input power. As offices are placed in front part of the building and trees shade natural day light, we presume that the artificial light is used there 8 hours a day, 260 days a year.

Tungsten bulbs can be replaced by various types of LED lights with significantly lower input power, in dependence on requested light intensity. We suggest to replace 100W bulbs by 15W SMD LED bulbs. For the illumination of cultural-social room 20W LED bulbs can be used (light intensity 2100 Lm). In this most capacious room the light is used occasionally, approximately 12 hours a day, 25 days a year. Sporadically are also used lights in corridors, library and toilettes. We presume that light is on for 3 hours, 250 days a year. We suggest to replace these bulbs by 15W LED bulbs.

Comparison of economic aspects (energy consumption per hour and total energy consumption) as well as environmental aspects (CO_2 production) is summarized in Table 2.

As we can see, by application of LED technologies in municipal office, we can achieve more than 4 -fold reduction of energy consumption as well as CO_2 production. Purchase price of all lights is 1136.95 €. If we consider yearly saving 4280.67kWh for 0.25€ per kWh, municipal office can save 1070 € per year. It means that return of investment will be approximately 1 year.

Heating system**.** From energy efficiency point of view, the next issue we will focus our attention is heating system. We suggest to replace currently used 3 stationary boilers 44.5kW by 2 condensing boilers with high efficiency and input power 38kW, which correspond to heating capacity of currently used 3 boilers.

Comparison of current state and state after implementation is summarized in table 3. In our counting we considered 5 months heating period (6 hours a 116 days).

Table 2
Comparison of energy consumption and CO2 production – municipal office lighting

Locality	**Energy consumption/hour ($kW.h^{-1}$)**		**Energy consumption/year ($kWh.year^{-1}$)**		**CO_2 production/year ($kg.kWh^{-1}$)***	
	Current state	After implementation	Current state	After implementation	Current state	After implementation
Offices	0.65	0.32	1347.84	673.92	835.66	417.83
Cultural-social room	4.80	0.64	1440.00	192.00	892.80	119.04
Others (corridors, library, toilettes)	3.70	0.56	2775.00	416.25	1720.50	258.08
Total	9.15	1.52	5562.84	1282.17	3448.96	794.95

* CO_2 emission coefficient of electricity is 0.62 kg/kWh [17]

Table 3
Comparison of heating units

	Old heating unit	**New heating unit**
Input power (kW)	3 x 44.5	2 x 38
Consumption per year (kWh)	92 751	52 751
Total annual cost (€)	4 888	2 788
Heat efficiency (%)	83	98.5
CO_2 production ($kg.kWh^{-1}$)*	22121.11	10602.95

* CO_2 emission coefficient of natural gas for old heating unit is 0.2385 kg/kWh and for new heating unit is 0.2010 kg/kWh [17]

Purchase price of two condensing boilers is 3800€. Eventual annual saving presents 2100€; therefore the return of investments is approximately 21 months.

Expect economic benefits, environmental benefits in terms of reduced CO_2 production are also remarkable.
By this case we want to demonstrate that municipalities have great opportunity to increase their energy efficiency, make steps to adaptation to climate change and simultaneously reduce their operational costs.
We have mentioned only two measures for improving energy efficiency of surveyed municipality, but there are other options, too. Lighting system can be improved also by installing motion sensors in corridors and rest rooms, which will bring even greater savings. Other measures, such as insulation of the outer walls of the municipality office and installation of photovoltaic panels for water heating on south side of the roof can also bring energy savings, but for the limited extend of this paper these measures are not the parts of our case study.

4 Conclusion

For municipalities, the energy issue is very important. Nowadays the fuel prices are ever-increasing, while there arises another problem - dependence on fuel supply from abroad. The European Union is aware of its dependence on energy supplies from beyond its borders and tries to push through improved energy efficiency and self-sufficiency. Based on the analysis of the energy policy of the European Union and the energy policy of the Slovak Republic, we have identified various instruments the Union uses to enforce energy savings and reduction of CO_2 emissions, especially through the application of efficient technologies in the area of heating systems and light sources. With the intention of speeding up the deployment of these changes, the European Union offers various financial funds to ensure that all municipalities contribute to energy savings in their buildings.
Possibility of applying energy policy instruments were illustrated in a case study of medium-size municipality in eastern Slovakia. Thanks to the proposed changes, such as installation of LED technology in public lighting, municipality can achieve a theoretical saving of 14.13%. The same technology used to illuminate office building results in energy savings of 77%. Replacing the heating unit brings a theoretical savings of 43%. The paper aimed to highlight the importance of applying these instruments at the level of municipalities both in relation to the reduction of negative impacts on the environment (reduction of CO_2), as well as the economic benefits associated with a reduction of operating costs and quite rapid return on investment. In addition, these measures equip municipalities to increase their degree of adaptation to climate change, which is one of the priorities of EU environmental policy. The village, which is the subject of case study presented in this paper may serve as an example and also a motivation for other municipalities.

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